

Laser Light Scattering With Multiple Scattering Suppression Used to Measure Particle Sizes

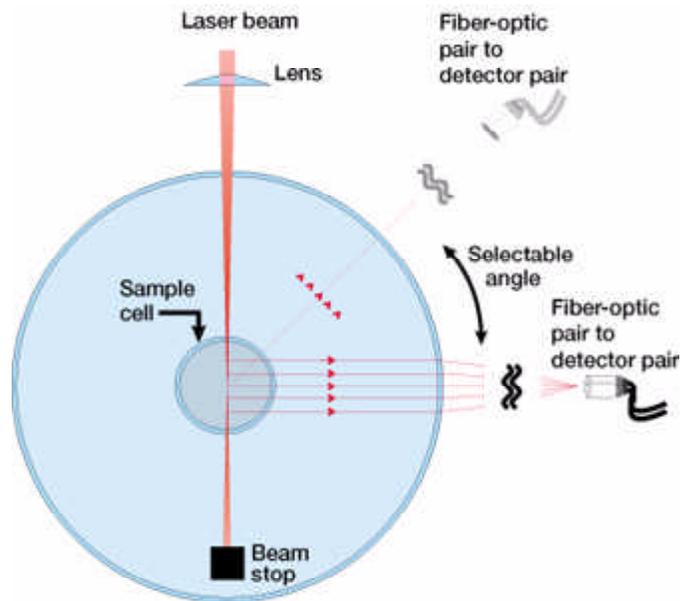


Diagram of multiangle laser-light-scattering instrument with multiple-scattering suppression using single-color cross-correlation. Both fibers are stacked perpendicular to the scattering plane.

Laser light scattering is the technique of choice for noninvasively sizing particles in a fluid. The members of the Advanced Technology Development (ATD) project in laser light scattering at the NASA Lewis Research Center have invented, tested, and recently enhanced a simple and elegant way to extend the concentration range of this standard laboratory particle-sizing technique by several orders of magnitude. With this technique, particles from 3 nm to 3 μm can be measured in a solution. But, until recently, it was difficult at best to look into the depths of fluids that are not as clear as water. With higher concentrations of particles, the large increase in multiple scattering would corrupt the data.

Recently, laser light scattering evolved to successfully size particles in both clear solutions and concentrated milky-white solutions. The enhanced technique uses the property of light that causes it to form tall interference patterns at right angles to the scattering plane (perpendicular to the laser beam) when it is scattered from a narrow laser beam. Such multiple-scattered light forms a broad fuzzy halo around the focused beam, which, in turn, forms short interference patterns. By placing two fiber optics on top of each other and perpendicular to the laser beam (see the drawing), and then cross-correlating the signals they produce, only the tall interference patterns formed by singly scattered light are

detected. To restate this, unless the two fiber optics see the same interference pattern, the scattered light is not incorporated into the signal. With this technique, only singly scattered light is seen (multiple-scattered light is rejected) because only singly scattered light has an interference pattern tall enough to span both of the fiber-optic pickups. This technique is simple to use, easy to align, and works at any angle. Placing a vertical slit in front of the signal collection fibers enhanced this approach. The slit serves as an optical mask, and it significantly shortens the time needed to collect good data by selectively masking out much of the unwanted light before cross-correlation is applied.

Different scattering angles and polarizations can be used to extract additional information from the samples--information that was previously unavailable and not theoretically interpreted. Both of these concerns are being addressed, and we believe that this will have a significant impact in the particle-sizing community.

In addition, the Advanced Technology Development light-scattering group at Lewis is extending the capabilities of laser light scattering by using fiber optics to overcome the problems of stray light (which until now could corrupt the interpretation of otherwise good data). Launching the laser beam used to probe the particles both into the solution and into a fiber optic that is coupled to the signal-receiving fiber will introduce a local oscillator at the detector. This overcomes the problems introduced by a small amount of stray light. It also provides significant (homodyne) gain for the signal and eliminates many of the cross-terms that would otherwise make data analysis more complicated. Although bulk-optic homodyne instruments have been used in the past, alignment problems made these difficult, onerous beasts (especially when multiple-angle measurements were being made). With fiber optics, homodyning is much easier. Mixing the scattered light signal and the laser beam in polarization maintains monomode fiber optics and is 100-percent efficient because of the wavefront matching imposed by the fiber-optic couplers.

Lewis' light-scattering group is continuing to provide new laser-light-scattering technologies and techniques that help answer fundamental science questions--questions that can be answered by studying colloid particle interactions and fluid-crystal-glass phase transitions in space (where gravity does not destroy the study with conventional effects). These studies serve as a good model for atomic interactions and crystal formation and have led to a number of pleasant surprises and advances. The commercial biotechnology community is also asking Lewis' light-scattering group about using light scattering to study proteins. Further interest is surfacing in the computer industry, where polishing compounds grind themselves up when they are used to make computer chips. Here, constant monitoring of the particle grit size is needed to increase silicon wafer production yield. Other opportunities are also being addressed.

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